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An investigation into the potential barriers facing the development of offshore wind energy in Scotland: Case study – Firth of Forth offshore wind farm

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ABSTRACT

The Scottish Executive has set ambitious targets of achieving 100% of electricity from renewable sources by 2020. As Scotland has the best offshore wind resources in Europe, the development of this energy source is crucial for reaching these targets. However, the development of offshore wind raises a number of issues related to economic viability, grid connection and public acceptability. This paper investigates these areas in greater depth, using a case study of the Firth of Forth offshore wind farm, in order to determine if these barriers can be overcome in time to make a valuable contribution to 2020 targets. Through interviews with relevant stakeholders, it emerged that there are various obstacles which are impeding progress in offshore wind development in Scotland. It became evident that stakeholder opposition, an inadequate renewable energy support mechanism, and the insufficient grid infrastructure off the Scottish coast are posing barriers, and hindering development. It became apparent that in order to overcome these barriers, a number of changes need to take place. A more inclusive approach to stakeholder engagement is required, which facilitates the sharing of knowledge. In order to improve the economic viability of offshore wind in Scotland, adopting a new mechanism which reduces risk and provides developers and investors with more certainty, would be more effective in encouraging offshore wind development. Finally, in order to overcome the most significant barrier, the grid, a more integrated and collaborative approach is required, which will share the burden of responsibility between the developer, Ofgem, and the National Grid.

Contents

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1. Introduction

1.1. Renewable energy targets and the role of offshore wind

Over the past decade, there has been an EU-wide drive to reduce carbon dioxide and greenhouse gas emissions in order to tackle dangerous climate change. In order to deal with this immense challenge, the UK Government has committed to sourcing 15% of its energy, including 30% of its electricity, from renewable sources by 2020 [1].

Offshore wind is set to make the single biggest contribution towards these renewable energy targets across the UK [2]. According to the Scottish Executive [3], offshore wind will play a crucial role in achieving these targets due to the fact that the UK has over 33% of Europe's potential offshore wind resource, with the majority of that resource lying off the coast of Scotland.

Although the UK are the leading European country in terms of offshore wind development [4], Rounds 1 and 2 of development have not proceeded at the rate intended. It was initially anticipated that there would be between 4.5 and 5.5 GW of operating capacity by 2010 [5]. By the end of 2009, there was less than 1 GW of installed offshore wind capacity in the entire UK [4].

The Scottish Executive [6] has set even more ambitious targets of achieving 30% of energy, including the equivalent of 100% of electricity from renewable sources by 2020. However, in early 2011 there was still only 190 MW of offshore wind deployed in Scottish waters from Rounds 1 and 2 [6].

In January 2010, the Crown Estate announced nine offshore wind development sites as part of the Round 3 programme. This included two major zones off the coast of Scotland. It has been envisaged that the Moray Firth zone (zone 1) and the Firth of Forth zone (zone 2) will produce 1.3 GW and 3.5 GW of electricity respectively, thereby making a valuable contribution to both UK and Scottish targets [7]. In order to focus this research, only Scottish targets were considered for the remainder of the study.

1.2. Case study – Zone 2: Firth of Forth

In this paper, the larger of the two sites, the Firth of Forth, is used as a case study. This development area is located between 23 km and 80 km off the east coast of Fife, Scotland between water depths of 30 and 70 m. It has a total area of 2852 km^2, only a fraction of which will be developed.

The developers anticipate that this zone will generate approximately 3.5 GW of energy from over 700 turbines. The consenting period is scheduled to run between 2011 and 2015. During this time, planning applications will be submitted and reviewed by the relevant authorities and public and stakeholder engagement will take place. Construction is scheduled to take place in three phases of development between 2015 and 2020.

This case study was chosen as it is one of the largest Round 3 zones. It is also at an early stage in the development process, which is the optimum time for identifying and anticipating the potential issues which may arise, and the barriers it is likely to face.

Development of this zone will depend on a range of factors including public acceptability, economic viability, and overcoming grid constraints (Fig. 1).

1.3. Research objectives

The objective of this paper is, using the Firth of Forth case study, to explore the issues which may affect development, particularly with regards economic viability, grid constraints and public acceptability. At what stages these issues arise, and how they may be dealt with, will then be examined and placed in the broader context of offshore wind development in Scotland.

This paper will therefore also assess the likelihood of offshore wind development in Scotland making a valuable contribution to 2020 targets.

2. Background and key issues

2.1. Economic viability of offshore wind

One issue which may pose a challenge for offshore wind developers is the economic viability of these projects. In recent years, there has been a sharp increase in the capital costs of offshore wind projects in the UK [8]. According to the DECC [9], average capital costs have doubled in the past 5 years. Fig. 2 shows how these capital costs such as foundations, turbines and grid connection can account for as much as 80% of the total cost of a project [10]. Foundations are significantly more expensive for offshore than onshore projects, with costs having risen by 180% over the past five years [9]. Rising costs can be attributed to the fact that the cost of raw materials has risen in recent years due to fast growing economies in Asia. The price of turbine components such as copper, lead and steel have risen by 200%, 376% and 100% respectively since 2004 [10]. According to the DECC [11], the Euro/Sterling exchange rate (the weakening of the pound against the euro) has also driven the costs of offshore wind development upwards. Current capital costs of an offshore wind development in the UK are estimated at £3.1 m per MW of capacity installed [8]. Fig. 3 shows the historical, present and predicted future costs of offshore wind projects in the UK.

This significant economic barrier can often hinder the market penetration of offshore wind. One way to address this is to provide a suitable support mechanism in order to make these projects more economically viable. Renewable energy support mechanisms attempt to bridge the gap between the project costs of offshore wind development, and the wholesale electricity price. Currently, the two principle renewable support mechanisms utilised in Europe are the fixed feed-in tariff and tradable green certificates (quota scheme).

2.1.1. Feed-in tariff

The FIT scheme is the most commonly used support scheme in Europe with 18 countries having adopted this approach [12]. The FIT scheme involves renewable energy generators selling their electricity at a legally regulated price per kWh to the supplier. It is a simple guaranteed price approach involving a fixed schedule of payments over a certain time period, usually 20 years [13].

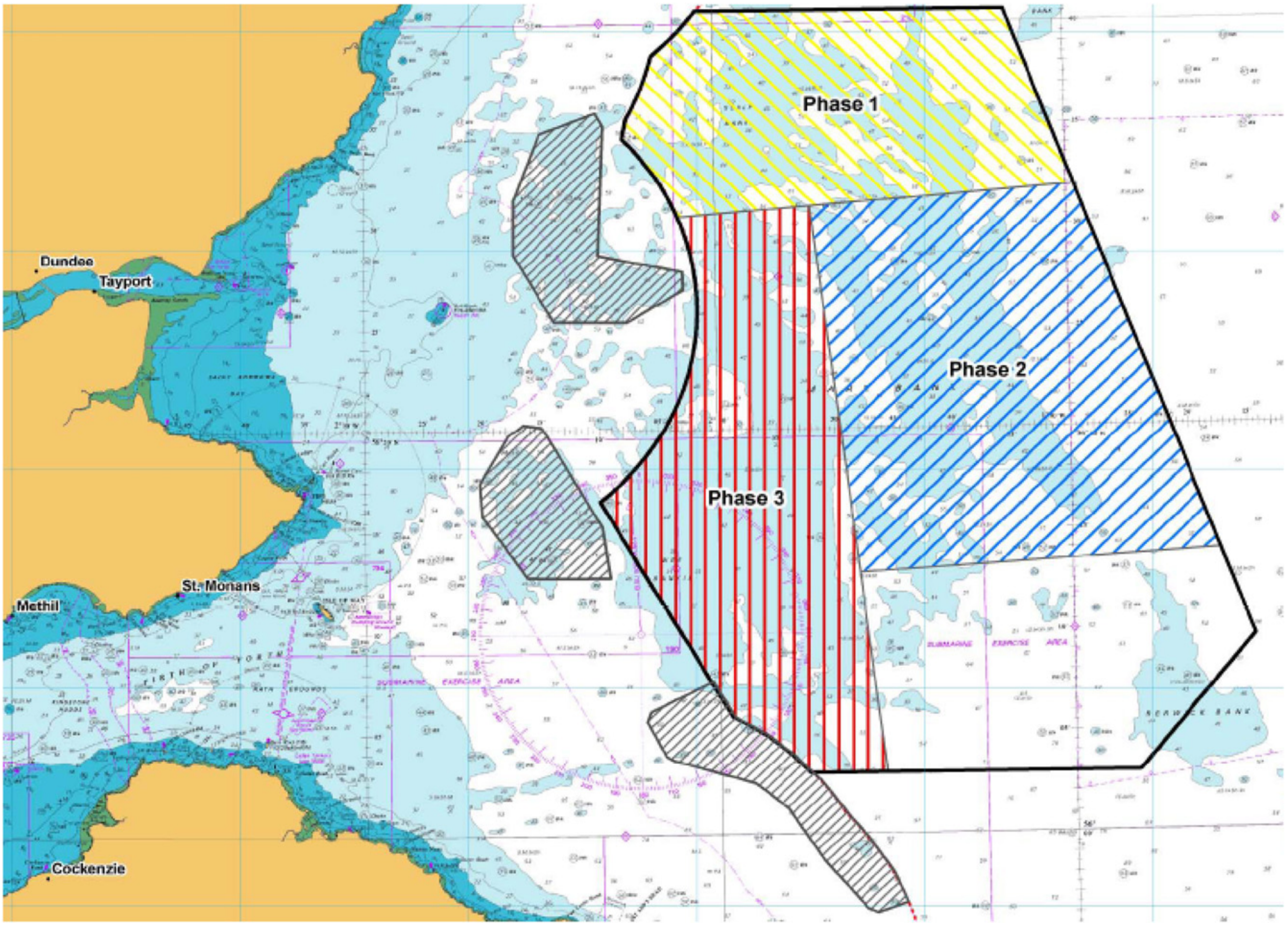


Fig. 1. Round 3 – Zone 2, Firth of Forth. This diagram shows the zone boundaries, the three development phases, and the three Round 2 sites inshore of the zone. Source: Seagreen ([47], p. 10).

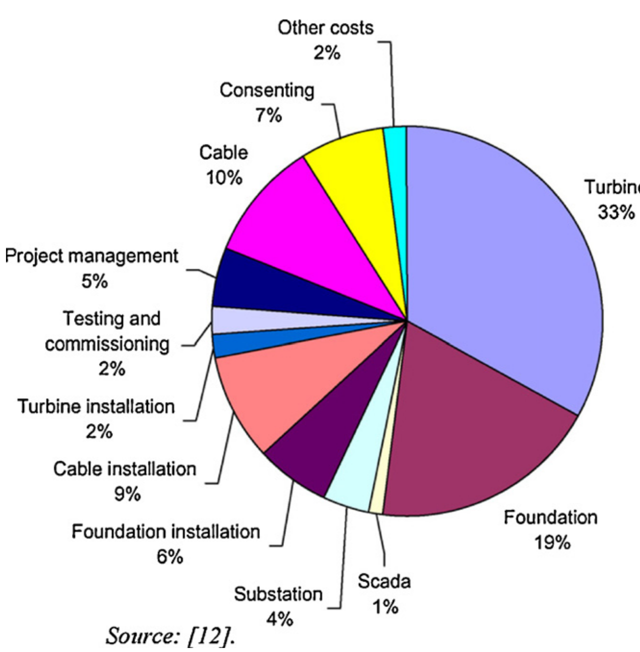


Fig. 2. Breakdown of average capital costs for an offshore wind farm. Source: Blanco ([10], p. 1375).

According to Elliot [14], it creates a favourable investment climate as payments are reduced in anticipation of technological advancements in a transparent and predictable way via a digression mechanism.

As electricity is sold at a guaranteed price, electricity market prices are irrelevant, and therefore renewable energy generators are isolated from market prices and risks [12]. This risk minimisation has been identified by many authors as being a positive attribute of the FIT scheme. Mitchell et al. [15] believe that risk reduction is crucial for making a support mechanism effective in promoting renewable energy deployment. According to authors such as Toke et al. [16] and Elliot [14], the FIT scheme provides a secure investment climate and predictable returns.

2.1.2. *Renewables obligation (RO)*

The RO has been the chief support mechanism for renewable energy in Scotland and the rest of the UK since 2002. In 2008, the UK Energy Act introduced “banding” which allows specific technologies more than 1 Renewable Obligation Certificate (ROC) per kWh, for example, offshore wind now receives 2 ROCs/MWh compared with just 1 ROCs/MWh awarded for onshore wind. The aim of this higher subsidy is to account for the higher costs associated with developing wind farms offshore [11].

The RO is a market based scheme meaning that renewable energy generators are vulnerable to electricity price risks and the certificate price risks. Authors such as Hiroux and Saguan [17] recognise that there are some positive effects of wind power producers participating in electricity markets: wind farm sites are chosen with consideration of temporal generation pattern,

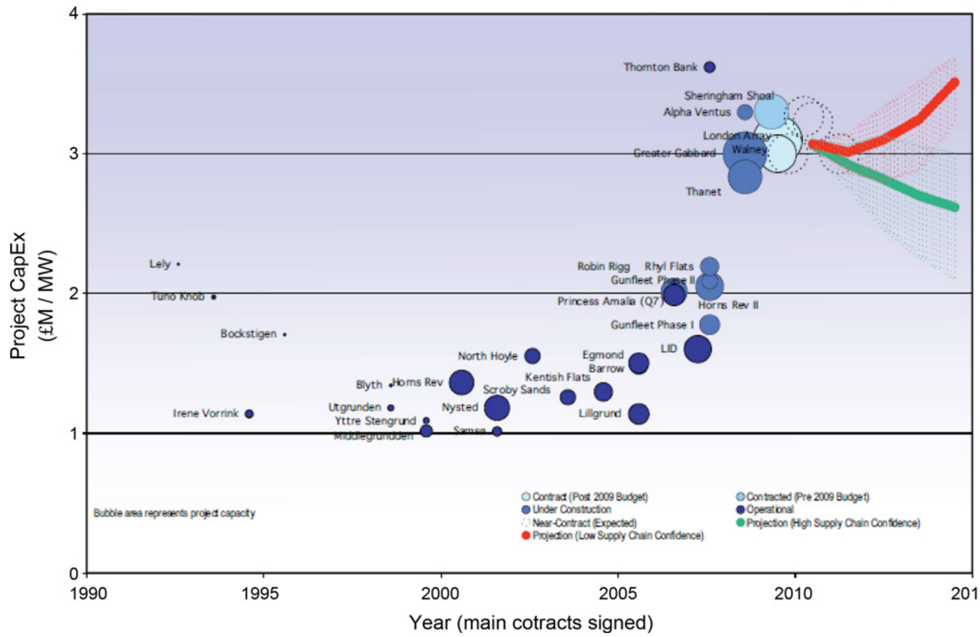


Fig. 3. Historical, present, and future predicted capital costs of offshore wind projects in the UK.

Source: BWEA [8].

congestion costs and losses, and maintenance planning and technology combinations. Agnolucci [18] acknowledges that market-based schemes create competition between generators which can lead to reduced prices for consumers and also technological innovation.

However, others believe that market based renewable energy support schemes are ineffective as they carry greater investment risk due to the unpredictable level of electricity consumption in the future and uncertainty surrounding regulatory changes that could shift the demand for ROCs [19]. The stability and future of the RO has just recently been called into question by the UK Governments Electricity Market Reform consultation which has proposed that it be replaced after 2017 [6].

Authors such as Elliot [14] have also criticised the RO for being cost ineffective. In 2003, the UK RO was delivering electricity at 9.6 c/kWh compared with 6.6–8.8 c/kWh under the FIT scheme in Germany. On a similar note, in 2006 the RO was costing UK electricity consumers 3.2 p/kWh compared with consumers in Germany who were paying just 2.6 p/kWh [20].

Verbruggen and Lauber [19] also highlight the cost ineffective nature of the RO scheme in reference to the fact that wind farms in the UK are built at excessively high prices compared with Germany and Spain which have less favourable conditions for generating wind power.

2.2. Grid constraints

In order for high levels of electricity to be generated from offshore wind, it is essential that a stable, secure and high capacity grid network is established in Scotland and the rest of the UK.

The Transmission Access Review (TAR) was carried out by Ofgem and BERR in 2008 with the aim of reducing grid-related access barriers in order to facilitate faster connection of renewable generation. According to the TAR [44], drastic measures need to be taken to prevent grid investment remaining a barrier to achieving 2020 targets. Adding up to 40 GW of wind capacity will require major changes to grid regulations and significant investment in new grid connections. The National Grid [21] Offshore Development Information Statement proposes major transmission network reinforcements along the coast of Scotland in order to incorporate Round 3 developments, however it is unsure whether sufficient capacity to accommodate all will be constructed by 2020.

The European Concerted Action for Offshore Wind Energy Deployment (COD) has identified particular areas of concern which include transmission bottlenecks, power system stability, and grid access [22]. Major transmission bottlenecks in the UK are in Scotland due to the fact that power flows are predominantly north to south, as energy is produced here from renewable sources, but then has to be transferred south to the demand centres in the central belt in Scotland and England.

Offshore wind projects in Scotland will require upgrading, replacement or reinforcement of the existing grid networks. According to the Offshore Wind Industry Group [23] "substantial expansion" is needed to connect this offshore wind and export electricity to the rest of the UK as there are major concerns that the existing grid infrastructure is unable to support the proposed levels of deployment. Although the Electricity Networks Strategy Group (ENSG) [42] report identifies the upgrades that are required in order to fully exploit this resource, the OWIG [23] identify that there is a risk that the timeline of these improvements is not in keeping with developers timelines and with 2020 targets.

There are substantial costs associated with upgrading and reinforcing the electricity grid in Scotland in order to cope with renewable energy generation. Ofgem [24] has stated that grid upgrades in order to accommodate offshore wind in the UK, including the numerous developments in Scottish waters, could cost in the region of £15 billion.

Another factor which may hinder development is the high level of ambiguity which surrounds the grid connection process. Over the past two years Ofgem has been working with transmission companies on new incentive arrangements in order to attract transmission investment to facilitate the grid connection of offshore wind farms. The new Offshore Transmission regulatory regime (OFTO) is an open and competitive approach which involves tender rounds for transmission assets. An OFTO license will be issued to the successful offshore wind generator who has bid to design, finance and construct the transmission assets [25]. However, the OWIG [23] is concerned that this process may result in significant costs for

developers and may also delay the development of offshore wind projects in Scotland. It has also been acknowledged by Scott [26] that transmission reinforcements often rely on developers identifying the required reinforcements and coming forward with financial commitment and that this disjointed approach can result in confusion for developers, and can delay works significantly.

A further concern for offshore wind developers in Scotland with regards the grid is the delays which may occur due to the amount of time taken to obtain planning permission for grid reinforcements. According to Woyte et al. [22], long lead times for the acquisition of land and obtaining permits can result in grid reinforcements taking as long as 15 years. Indeed, Gibson and Howsam [5] believe that there is a lack of a strategic and holistic approach to grid connection, and that this is required if 2020 targets are to be met.

In relation to the Round 3 offshore wind development process, the National Grid and Crown Estate [45] have reviewed the optimum options for reinforcing the grid to facilitate the connection of these offshore wind farms. With regards to the case study, the Firth of Forth site, they estimate that the approximate cost of connecting this windfarm to the grid would be in the region of £150 million. This involves connecting the windfarm to the substation at Torness (Fig. 4).

This grid connection study stresses the importance of co-ordination and collaboration between the National Grid, Ofgem and the developers in this "critically congested part of the network" [45]. If upgrades to the grid are made on a "wind farm-by-wind farm" basis, this disjointed approach could result in unnecessary costs, delays, and a lack of strategic planning.

2.3. Public acceptability

Controversy over the public acceptability of wind farms has been recognised in the UK Governments 'Energy White Paper' (2003) as being a significant barrier to the target of a 60% reduction in carbon emissions by 2050. Despite the fact that, according to a range of opinion polls, 80% of the UK population support wind energy [27], public opposition to such developments is commonplace.

While offshore wind projects are often regarded as more publicly acceptable than onshore projects, studies have shown that public opposition to offshore wind farms is still prevalent in the UK [28]. Public opposition may arise due to a number of reasons including seascape impacts, environmental damage, and a lack of consultation. Although the Firth of Forth zone will be located over 20 km offshore, due to its vast scale, public opposition could potentially present a barrier to the development of this project and similar projects.

The discrepancy between apparent high levels of public support for wind energy generally and the low success rate of planning applications for wind farms is referred to by Bell et al. [27] as the 'social gap'. A theory often put forward to account for this 'social gap' is NIMBYism (or Not In My Back Yard syndrome). This is the belief that people will generally support wind energy, so long as it

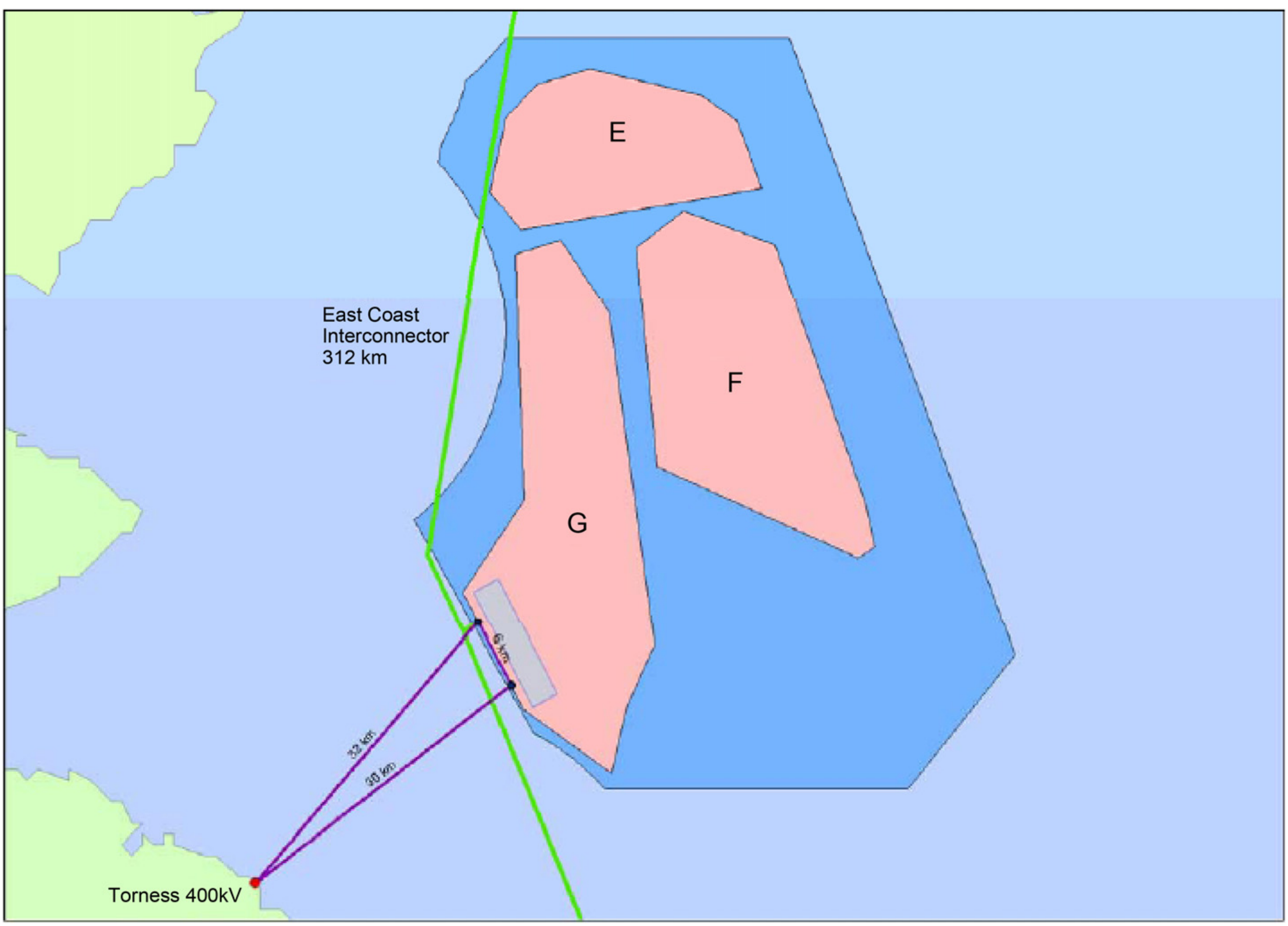


Fig. 4. Firth of Forth zone connection overview. The figure shows the two potential connection routes to the 400 kV substation at Torness. Polygon E represents Phase 1 of development and connection, followed by G (Phase 2) and then F (Phase 3).
Source: The National Grid and Crown Estate ([45], p. 44).

is not in their local area. However, the NIMBY label has been criticised by numerous authors. Warren and Birnie [29] believe that it is too simplistic a theory to capture a wide range of views and opinions. Kempton et al. [30] reject this theory on the basis that it implies selfishness as an underlying cause and tends to obscure the actual reasons for opposition.

Many alternative theories have been proposed to account for how wind farms are accepted and perceived by the public. It has been widely acknowledged by authors such as Wolsink [46] that it is the visual impacts of wind farms that are the driving force behind public opposition. According to Warren and Birnie [29], in Scotland, the primary motivation of opposition groups is the belief that wind farms spoil scenic landscapes.

According to Devine-Wright [31], local opposition can be seen as a form of "place-protective action". This may arise when a wind farm development threatens place-related identity processes. A place can contribute to an individual's sense of identity, often referred to as 'place identity'. It is associated with the concept of "place attachment" which Manzo ([43], p. 84) describes as a "positive emotional connection with familiar locations such as the home or neighbourhood". The development of a wind farm can be viewed as a threat or disruption to place attachment and public opposition may ensue.

It has been widely acknowledged by authors such as Haggett [28] that effective engagement with the local community at the early stages of the planning process can greatly reduce public opposition to a development. Similarly, Wolsink [32] has found that a lack of communication between local people and developers often acts as the 'perfect catalyst' for converting public opposition into local action against specific projects. Engagement that fails to listen to people and value their opinions can leave the community feeling alienated, agitated and can encourage protest. In a study by Haggett [28], this was found to be the case, when the developer of the Gwynt-y-Mor offshore wind farm in North Wales held a series of open days with the local communities. Concerns raised by local people were not responded to or acted upon, leaving the people feel that there had been a lack of any 'real' consultation. This case proves that siting wind farms offshore can be just as contentious as onshore due to the fact that many of the issues that pose problems to siting wind turbines onshore are equally as relevant offshore.

Bell et al. [27] also highlight the importance of public involvement. They propose a system of 'collaborative planning' in order to involve more people. With regards stakeholder consultation, Gray et al. [33] have identified the need for systematic consultation processes, especially when dealing with vulnerable groups such as fishers. Similarly Sorenson et al. [34] have highlighted the importance of meaningful dialogue from the early stages between developers and stakeholders. Haggett [35] states that the role of both the public and key stakeholders is just as important in relation to offshore developments as onshore.

2.4. Key issues

Due to the high capital costs associated with developing offshore wind farms, it is essential that an adequate support mechanism is in place. A support mechanism is required which not only encourages development, but also ensures that projects are economically viable. Some issues regarding the efficacy and cost-effectiveness of the RO have emerged in the literature. These issues need to be explored in greater depth in order to determine if this support mechanism is hindering offshore wind development in Scotland.

It is evident that significant upgrades to the grid in Scotland are required in order to cope with the high levels of offshore wind proposed. These upgrades are likely to be extremely costly and susceptible to delays, which could hinder rates of offshore wind development. The lack of clarity and lack of an integrated approach with regards planning for grid connections and upgrades will also exacerbate the situation. These issues will be explored further in a later section.

Public and stakeholder opposition is still a relevant issue, and often a prominent barrier, with regards offshore wind developments, as well as onshore. It can arise due to a number of reasons: visual impacts, place attachment, and lack of consultation. The issue of public opposition in relation to the Firth of Forth offshore wind project will be analysed in a later section.

3. Methodology

A qualitative approach was used in this research and a series of in-depth semi-structured interviews conducted with key informants. According to Hoggart et al. [36], interviews are an 'intensive method' of primary data collection which give a great insight into the beliefs and actions of those being interviewed.

A semi-structured interview is a flexible approach which involves the interviewer having a list of questions or specific subject areas which need to be covered, which is referred to as an 'interview guide'. A semi-structured rather than unstructured approach was chosen as it allowed topic areas to be covered thoroughly with specific questions. Questions relating to the key areas of public acceptability, support mechanisms, and grid constraints were asked in each one. Open-ended questions were asked which give interviewees the opportunity to steer the interview into the realms that are important to them [36], and proved extremely beneficial in this study.

In order to find suitable interviewees, a range of relevant stakeholder organisations were identified. These organisations included the developers of the Firth of Forth wind farm; a Government body set up to manage Scotland's marine environment; a state body who are responsible for the UK sea-bed, an interest group representing different organisations in the Firth of Forth; a Government body responsible for Scotland's nature and landscapes; an anti-wind action group, a Government body responsible for Scottish coastal issues; and finally a representative from a fisheries group. Key contacts were identified and invited to participate in the research.

While the majority of interviews conducted were face-to-face, a small number were carried out over the phone. Interviews were carried out in June, July and August 2010, and on average lasted 1 h each.

The interviews were recorded and the data collected was then transcribed from the recordings. Interesting points and key themes which emerged in the transcriptions were then highlighted and noted. From this, the data was divided into four sections and analysed: public acceptability, economic viability, grid constraints, and 2020 targets.

4. Analysis

4.1. Economic viability

The economic viability of offshore wind projects is a crucial consideration when developing large wind farms off the coast of Scotland.

During the interviewee process, interviewees discussed this economic barrier, and whether it was surmountable. The current support mechanism – the RO – was discussed, as well as the support mechanism which has been implemented in the majority of EU countries–the FIT scheme.

The general consensus was that the economic viability of offshore wind projects is a major concern to all involved. Although most interviewees felt that these costs were necessary in order to develop this clean energy source, not all agreed. According to the

anti-wind group representative, their core objection to wind power has always been that it is "an expensive white elephant", and that this argument still stands whether wind turbines are sited on land or at sea.

The representative of the Scottish Coastal Forum described offshore wind development as a "front-loaded investment process", as during the initial stages, developers are pouring money into it, and seeing no return. The interviewee stated that the profits that will eventually arise, but that this will be several years down the line.

Interviewees were asked if they felt that the current support mechanism – the RO – was an adequate system for improving the economic viability of offshore projects, and therefore encouraging sufficient levels of deployment. As the RO has been criticised in the literature for creating windfall profits for large corporate developers [18], being cost-ineffective [14] and risky [19], interviewees were asked if they felt that the level of subsidy awarded to offshore wind projects (2 ROCS/MWh) was adequate, too much, or too little. The Crown Estate representative felt that this level of subsidy is definitely not too generous due to the high capital costs associated with developing offshore. Similarly, the spokesperson for Marine Scotland suggested that it could even be a little higher. However, this particular interviewee did acknowledge that there are always ways that the RO could be improved, such as providing more certainty for investors. The SNH representative stated that although the FIT scheme might be a better option, it could be risky to switch at this stage as the banks are familiar with this system, and need consistency and stability in order to invest.

The representative of the anti-wind group agreed strongly with the view of authors such as Agnolucci [18] that the RO creates windfall profits for developers. She referred to the RO as a "scam". She used an example of the £3 billion 1.5 GW London Array project to back up her theory; assuming a load factor of 35%, this project earns £650 a minute on top of electricity charges. Even when you subtract £500 for operation and maintenance costs, it is generating profits of approximately £150 a minute, which the electricity consumers are paying for.

Although the developer explained that his organisation does not like to share their view on the RO, he did imply that if the value of ROCs was increased, this may lead to profiteering "If you have more ROCs, the equipment manufacturers or other suppliers may increase their prices, so that they can take a bigger slice of the increased ROCs".

Interviewees were then asked about the possibility of switching to a FIT system. According to the Crown Estate representative, who has discussed the possibility of switching to a FIT scheme with many developers, the general consensus amongst them is that it would be something they would welcome due to the success it has had on the continent in stimulating high levels of deployment.

The representative from the Scottish Coastal Forum explained that the FIT scheme may well be a better option than the RO due to the high level of investment that is required in offshore wind projects, and the concerns that developers have about losing that investment. She explained that within the current RO system, developers are exposing themselves financially for a considerable period of time before they get anything back. Therefore, a FIT scheme might be a more favourable option.

4.2. *Grid constraints*

Grid constraints have been identified by authors such as Swider et al. [37] and Gibson and Howsam [5] and in policy documents such as the TAR [44] as being a major barrier to the development of offshore wind in Scotland. The Scottish Executive [38] has stated that the inadequate grid infrastructure along the coast of Scotland is a severe limitation to the exploitation of offshore wind. Interviewees were asked whether they agreed with this statement and if the grid is likely to pose a challenge for the Firth of Forth development in particular.

All of the interviewees agreed that the inadequate grid infrastructure is a severe limitation to the development of offshore wind in Scotland. The Scottish Coastal Forum representative recognised the grid as being a "serious challenge" due to the "unfortunate mismatch" of having the best wind resources in Scotland but the greatest requirement for them in the far calmer south-east of England. According to the spokesperson for Marine Scotland, it is the main hurdle the Scottish Government face in terms of wind farm development.

The lack of a co-ordinated and strategic approach to grid connection has been recognised previously as being a serious constraint [5,37] and poor integration approach between National Grid, Ofgem, and the offshore wind developers emerged as a key issue during the interview process. The SNH representative recognised the urgent requirement for a more integrated approach as currently each developer is responsible for the grid upgrades specific to their particular project.

Indeed, the representative of the Scottish Coastal Forum felt that it is very unfortunate that there does not appear to be more "joined up thinking". This interviewee believed that one of the prime reasons for this lack of integration is due to the fact that Rounds 1, 2 and 3 of offshore wind development have gone forward before the marine planning infrastructure has been put in place, therefore the Government now have to retrospectively do marine planning.

Another issue which has arisen as a result of this lack of integration is that there is a lack of clarity regarding the connection of offshore projects to the grid. Interviewees stressed the need for a clear, comprehensive approach. The Marine Scotland representative has described the situation as a "chicken and egg scenario" whereby the grid operators will not upgrade the grid unless there is a substantial amount of interest, and unless they have concrete plans from the developers. However, the developers want to develop in specific areas, and if there is inadequate grid infrastructure in the area and they cannot get their electricity onshore, they are forced to go elsewhere.

Regarding the Firth of Forth development, the Crown Estate representative has stated that there could be an issue regarding the connection of this wind farm to the onshore hub at Torness power station due to the fact that going so far south (the closest point is approximately 32 km and furthest approximately 80 km) could be extremely expensive.

The Forth Estuary representative also had reservations concerning the connection of this wind farm to the power station at Torness. This interviewee believed that it is highly unlikely that this power station will be able to accommodate all the Round 2 developments, before this particular Round 3 project is considered. He explained that amongst the Round 2 developers there will be a race to connect to the grid first as whoever is last will be responsible for upgrading the shore side of the grid. This interviewee anticipates that this will be a major challenge for this particular Round 3 development as it will result in higher costs and increased delays.

Interviewees were then asked what can be done to overcome the significant barrier of grid constraints. According to the Marine Scotland representative, close dialogue between the Government, grid operators, Ofgem, and developers is required. On a similar note, the developer expressed the need for more clarity regarding who is going to pay for these grid upgrades, and a need for this huge burden to be shared amongst the interest groups.

As was recognised by Woyte et al. [22], land acquisition and obtaining planning permits can result in grid reinforcements taking as long as 15 years. According to the Crown Estate representative, when connecting offshore wind farms to the grid, there needs to be better co-ordination of grid connection routes and cable corridors

so that "we do not have our grid connections firing off all over the place". He recommended sufficient planning and co-operation between developers in order to remove this constraint.

4.3. Public acceptability

It is evident from the literature that the public acceptability of wind farms has been widely recognised as being a significant barrier to the development of both onshore and offshore wind energy in the UK.

However, the general consensus among the interviewees was that the Firth of Forth development, which will be located between 23 km and 80 km offshore, was unlikely to be subject to major opposition from the general public, due to the fact that it will be located so far offshore. A representative from an interest group representing different organisations in the Firth of Forth believes that for the public it is likely to be a case of "out of sight, out of mind". This corresponds with Wolsink's [46] theory that the visual impacts of wind farms are the driving force behind public opposition. Therefore if the turbines are merely "dots on the horizon", as described by this particular interviewee, then the visual impact may be unlikely to be an issue.

However, not all interviewees took it for granted that public opposition would not emerge. A spokesperson from Crown Estate was surprised at the low level of public opposition to the development so far, especially considering the concentration of communities and populations in the area, and the strong negative response which offshore wind farms along the west coast of Scotland are provoking.

An interesting outcome of the interview process was the level of concern amongst all interviewees regarding opposition from stakeholders such as the fishing and shipping industries. These stakeholders, particularly the fishing industry, were identified as being much more likely to oppose this development than the general public.

According to a representative from the Scottish Coastal Forum, fishers do not like their area "being sterilised", especially when they have always had the access rights in the past. A spokesperson from the Forth Estuary Forum believes that the fishing industry are going to "moan endlessly" as this Round 3 site is located further out where their fleets go, and takes in some prime fishing grounds.

As it was speculated by other interviewees that opposition from the fishing industry would be a major barrier to the development of the Firth of Forth wind farm, it was interesting to hear the views of a representative from the fishing industry. This interviewee was confident that there will be opposition from the fishing industry to this particular development, due to the fact that fishers feel that they are often overlooked during the process of offshore wind development in Scotland. According to this interviewee, the reason behind this is that developers only take into account the registered Scottish fishing fleet, and the areas where they fish. However there is a major flaw associated with this approach, which was also identified by the spokesperson for the Forth estuary interest groups: 80% of the Scottish fishing fleet is not registered, and so is not fitted with radar tracking. Therefore, the only way of finding out where these fishers' fish is through increased dialogue between the developers and the fishing industry, which could present a challenge. The fishing industry representative believes that the development of the Firth of Forth zone will "severely impact the fishing industry" as it poses a range of issues for the 230 boats that fish within this area. He explained that fishing boats will no longer have access to good fishing grounds, especially during construction.

Numerous ways of understanding and addressing opposition to wind farms are identified in the literature. Authors such as Haggett [28], and Wolsink [32] have stressed the importance of early engagement and effective communication between the public, stakeholders, and the developers. Many of the interviewees valued the importance of engagement at this early stage of development. According to the Scottish Coastal Forum representative, the key is to bring people in at an early stage in order to avoid 11th hour inquiries and delays.

Early consultation with fishers has been identified by authors such as Gray et al. [33] as being fundamental. However, according to the fishing industry representative, although there is engagement between the fishing industry and the developers, it is simply not happening early enough. This interviewee stressed the need for increased dialogue from the outset.

Both this interviewee and also the Forth estuary interest groups representative highlighted the fact that there are significant gaps between the knowledge of fishers and the developers which need to be rectified. This appears to be presenting a major barrier for offshore wind development. Both interviewees acknowledged that with more dialogue between these two parties, this situation could be ameliorated.

The developer acknowledged this responsibility in relation to public and stakeholder engagement, and explained that opposition will be overcome through "open information provision" in order to clarify any misconceptions. This 'information provision' approach to public and stakeholder engagement has been criticised in the literature [27,28] for failing to value people's opinions, and can often result in protest. An approach which encompasses real consultation, as suggested by many of the interviewees needs to be pursued if opposition is to be minimised and understood.

4.4. 2020 targets

At the time of interviewing, the Scottish Executive had set a target of 50% of electricity from renewable sources by 2020. This has recently (June 2011) been increased to 100%. Interviewees were asked if they believed that the Scottish Executive target of achieving 50% of electricity from renewable sources, such as offshore wind, by 2020 was feasible. The Marine Scotland representative believed that although it will be a challenge, it is feasible. On a similar note, the developer acknowledged that it is feasible, if the significant hurdles, already discussed here, can be overcome.

The spokesperson for the Crown Estate stated that meeting the targets is going to be slower than expected because the offshore wind programme is already approximately a year behind schedule. Although the Scottish Executive has stated that offshore wind will make a major contribution to these targets, the interviewee insisted that delivering this target is not just down to offshore wind, and that they will need to rely on hydro and biomass as well.

Similarly, the Scottish Coastal Forum representative felt that 2020 targets will be met, but using existing renewable infrastructure and development, such as hydropower, due to the fact that offshore wind technology has not advanced as quickly as anticipated.

When asked if they believed that the Firth of Forth development would be online in time to contribute to 2020 targets, many of the interviewees were sceptical. The Forth Estuary representative did not think it was likely due to the fact that Round 2 is already delayed and running behind schedule.

The Crown Estate representative also felt that there will be setbacks with regards to this particular development due to its vast scale and the environmental challenges it poses. Similarly, the spokesperson for the Scottish Coastal Forum considered it very optimistic. On the contrary, the developer assured that it would definitely be online by this time. However this interviewee did acknowledge there are huge challenges all across the board to be

met, particularly regarding the grid, describing it as the "major challenge".

5. Discussion

5.1. The RO – an adequate support mechanism?

The significant capital costs associated with developing offshore are a major concern to all involved in offshore wind development. A suitable support mechanism is required which will ensure that projects are economically viable, so that high levels of deployment are encouraged, and targets are met.

From the literature, it became evident that there is a high level of dissatisfaction with the current support mechanism for offshore wind in Scotland – the RO. It has been criticised for favouring large corporate developers rather than smaller companies [39], being risky and cost-ineffective [14] and also resulting in windfall profits for developers [19].

It emerged during the interview process that there are some major flaws associated with this system. Although it was felt that the level of subsidy awarded in the RO was not too generous, it was agreed that the profits made by developers would eventually be very good down the line. Many interviewees believed that the prospect of large profits was essential in order to encourage the developers to take on the substantial risk, and commit long term. However, this is to the detriment of cost-effectiveness. It also emerged that the RO system may even encourage profiteering from equipment manufacturers and other suppliers.

It was agreed that a shift in approach is required. Because of the level of investment that is required, a feed-in tariff was considered the most favourable option. This guaranteed fixed price approach offers developers more stability and security than a market based system. It is also a more cost-effective approach as the subsidy is reduced in stages over the projects life. It was considered that this system would encourage greater levels of development, as the barrier of economic viability would be reduced.

Although it is apparent that this change is urgently required, it is imperative that it is planned meticulously and well timed. It is important to note that if the RO is replaced by an alternative system in 2017 as recently recommended in the UK Governments Electricity Market Reform consultation paper, this change in tactic pre-2020 could initially be counter-productive. Investors need consistency, stability and familiarity with the system in order to invest. The introduction of a new system needs to be well timed, as it is inevitable that there will be a period of uncertainty and ambiguity. While in the long term a shift to the FIT scheme would be beneficial for offshore wind development in Scotland, changing to this system during the crucial years leading up to the 2020 deadline could be risky, creating an unfavourable investment climate, and potentially hindering rates of development.

5.2. Grid constraints – the need for an integrated approach

The grid infrastructure in Scotland has been recognised in the literature as being a serious constraint to the exploitation of offshore wind [22,40]. The interviewees considered that the grid is the main challenge faced by the Scottish government and the offshore wind industry.

The key issue regarding the grid appears to be the lack of an integrated approach between the developers, Ofgem and the National Grid. Currently, the process of connecting an offshore wind farm to the national grid is extremely disjointed. Developers are responsible for the grid upgrades specific to their particular projects, and there is an absence of more strategic planning. This is causing confusion and delays for those involved.

This unfortunate situation has evolved due to the fact that marine planning infrastructure was not put in place before Rounds 1, 2 and 3 of offshore wind development. Marine plans are designed to give greater clarity to decision making in the coastal environment. They identify opportunities and constraints, and reduce uncertainty for developers. Instead, marine planning has taken place retrospectively, and on an ad hoc and sporadic basis. This system lacks organisation, cohesion and clarity.

It has been acknowledged by interviewees that a clear, comprehensive approach is vital in order to overcome this barrier. The developers, Ofgem and National Grid need to work together to develop a strategy for connecting offshore wind farms as quickly and easily as possible. There is a huge requirement for the co-ordination of grid connection routes and cable corridors in order to minimise disruption and environmental impacts.

As developing and reinforcing the grid will require significant capital expenditure, it is apparent that these costs will need to be shared amongst the relevant parties. At the moment, the onus is on the developer, and this acts as a major disincentive to develop offshore. What upgrades are required, and who is going to pay for them, needs to be planned comprehensively between the relevant stakeholders so that they can be delivered within a certain timescale.

It is evident that the Firth of Forth development will be subject to this complex range of issues due to the ambiguous nature of the grid connection process in Scotland. Another potential issue which may arise, specific to this development, is regarding the onshore hub at Torness. This has been identified by the Crown Estate and the developers as the most suitable point onshore to which this wind farm could connect. However, not only has this been recognised as an expensive option due to the fact that it is so far south, it is also unlikely to be able to accommodate and cope with all of the Round 2 developments, yet alone this major Round 3 development. This could present a major challenge as further upgrades are likely to be needed, which will be costly and time consuming.

5.3. Stakeholder opposition rather than public opposition

It has been widely recognised over the past number of years that public opposition to wind farms poses a significant barrier to their widespread development [27,41].

However, public opposition is not anticipated by the interviewees to be an issue regarding the Firth of Forth development. This is due to the fact that this wind farm is located so far offshore where it will be barely seen. Therefore aesthetic concerns may not be applicable, and 'place identity' is unlikely to be threatened [48].

Where there is likely to be a major challenge is overcoming opposition from the fishing industry. This is an issue which has not received a significant amount of attention in the literature. Although authors such as Gray et al. [33] and Sorenson et al. [34] have acknowledged that fishers are the most affected group when it comes to offshore wind development, it is opposition from the general public which tends to receive more attention in the literature, media, and in Government publications. The fishers were identified by interviewees as being much more likely to oppose this development than the general public due to the fact that this wind farm will be located in prime fishing grounds. The onus lies with the developer to initiate the engagement process with these stakeholders, preferably an approach encompassing consultation, rather than just simply information provision. Effective engagement and genuine consultation can yield trust, acceptance and support [28,30].

Fishing interest groups believe that this wind farm will severely impact the fishing industry. This is due to the fact that the majority of the fishing fleet has been overlooked by the developers, as 80% of the fleet is not fitted with radar tracking. This has meant that the 230 boats that fish in the area, and depend on it for their livelihood,

have been mostly ignored and alienated. A change in approach is required immediately, which will take into account all sizes and types of fishing vessels.

Early engagement between the developers, stakeholders and the public has been recognised as being vital [28,32]. However, according to the interviewees, this engagement is not happening early enough between the developer and the fishing industry. Although authors such as Sorenson et al. [34] and Gray et al. [33] have already recognised the need for early engagement involving substantial, meaningful dialogue between the developers and the fishers, and for data deficiencies to be addressed, this situation does not appear to have improved in the six years since the publication of the latter article.

According to the interviewees, these reforms are still waiting to occur. Information needs to be shared during the pre-consenting phase as this significant data gap between the fishers's knowledge, and the developer's knowledge, is causing delays during the consenting phase and hindering progress in offshore wind development. If a channel of communication was set up between these two parties at the earliest stage possible, which facilitated the sharing of knowledge and information, this situation could be rapidly ameliorated. This could help to minimise opposition, and the level of impact on this industry.

5.4. 2020 targets

Although it has been proposed by the UK and Scottish Governments that offshore wind will make a substantial contribution to 2020 renewable energy targets, this is highly unlikely to be the case.

While the interviewees considered that meeting the ambitious target of 50% (now 100%) of electricity from renewable sources was achievable, the general consensus was that this target will only be reached through the use of existing infrastructure and development, such as hydropower.

On the basis of this research, it is apparent that offshore wind development in Scotland is not expected to contribute significantly to 2020 targets. This is due to the fact that technology has not advanced as quickly as possible, and due to the range of barriers which are yet to be overcome, particularly regarding the grid.

6. Conclusions

The objective of this study was to uncover any issues or barriers which may arise during offshore wind development in Scotland, particularly with regards public acceptability, economic viability, and grid constraints, using the Firth of Forth development as a case study. The aim was to determine if these barriers could be overcome in a timely manner, and to assess the likelihood of offshore wind development in Scotland making a valuable contribution to 2020 targets.

It was found that public opposition is not expected to pose problems for the Firth of Forth development. However, what is anticipated to pose a major challenge is opposition from the fishing industry.

In order to overcome this challenge, a more inclusive approach is needed. An approach which takes into account the needs and concerns of all fishing vessels in the area. Increased dialogue and continuous communication between the developers and the fishing industry is needed from the earliest stage possible, so that information and knowledge regarding the area and the resources can be shared. This would not only minimise delays in offshore wind development, but also the level of impact on the fishing industry.

It is evident that the economic viability of offshore wind projects in Scotland is a major concern to all involved. A review of the support mechanism, the ROS, is urgently required. A switch to a FIT system has been identified as the preferable option. This system is more cost-effective and offers developers more security and stability than a market based system. Provided this system is well planned and timed with consideration for 2020 targets, it could reduce the barrier of economic viability, and encourage greater levels of offshore wind development in Scotland.

The grid has been identified as being the major barrier facing offshore wind development in Scotland. There are a number of issues which need to be addressed urgently. The lack of an integrated approach between the developers, the National Grid, and Ofgem is a key issue. A strategic, co-ordinated approach is needed. Another area which is surrounded by ambiguity is regarding the costs of grid upgrades, and who is responsible for paying for these upgrades. This burden needs to be shared between these relevant parties.

Although these barriers concerning stakeholder opposition, economic viability and grid constraints are surmountable, it will be challenging. Due to the fact that they are yet to be overcome, it is highly unlikely that Round 3 offshore wind developments (including the Firth of Forth zone) will be contributing to 2020 targets.

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